EXPERIMENTAL STUDY AND MODELING OF DIESEL ENGINE FUELED WITH RUBBER SEED OIL

A THESIS SUBMITTED IN PARTIAL FULFILLMENT OFTHE REQUIREMENTS FOR THE DEGREE OF

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In

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By

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Rourkela

CERTIFICATE

This is to certify that the thesis entitled, **"Experimental Study and modeling of Diesel Engine Fueled with Rubber Seed Oil"** submitted by Sourprakash Dehury in partial fulfillment of the requirements for the award of Bachelor of Technology Degree in Mechanical Engineering at the National Institute of Technology, Rourkela is an authentic work carried out by him under my supervision and guidance.

To the best of my knowledge, the matter embodied in the thesis has not been submitted to any other University/ Institute for the award of any Degree or Diploma.

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ABSTRACT

The huge expand in number of vehicles as of late has brought about extraordinary interest for petroleum items. With unrefined petroleum stores assessed to last just for few decades. Numerous nations import more unrefined petroleum causes colossal remote trade out-go from one viewpoint and expanding fumes emanation on the other. Hence there has been a dynamic quest for interchange fills like biodiesel to give a suitable diesel substitute to inside ignition motors.The rubber seed oil based bio-diesel offer an extremely swearing up and down to alternative to diesel. The acid value for rubberseed oil is high. Two stage esterification i.e. acid catalyzed transesterification took after by basic/base catalyzed trans-esterification is created to prepare biodiesel from high FFA rubberseed oil. The motor energized with diesel and mixes of rubber seed oil based bio-diesel. The destination of the present study is examining the utilization of mixes of rubber seed oil based bio-diesel on execution and outflow qualities of a diesel motor contrasted with that of diesel. Motor execution with biodiesel does not contrast significantly from that of diesel fuel. The trial outcomes demonstrated that the utilization of rubber seed oil based biodiesel is suitable elective to diesel. The lack of the fossil fuel, ecological contamination and sustenance emergency are the world's significant issues in mongrel-rent period. Biodiesel is an elective to diesel fuel, environment agreeable and biodegradable and is prepared from either eatable or non-consumable oils. In this study, non-edible rubber seed oil (RSO) with high free fatty acid (FFA) substance of 45% was utilized for the generation of biodiesel. The procedure includes two steps. The principal step is the acid esterification to lessen the FFA worth and the second step is the base trans-esterification. The reaction surface system (RSM) was utilized for parametric enhancement of the two stage forms i.e. acid esterification and base trans-esterification. The yield of biodiesel was dissected utilizing gas chromatography. The FTIR (Fourier Transform Infra-Red) range was likewise discourage-mined to affirm the transformation of fatty acid to methyl esters.

CONTENTS

List of Figures and Tables

Figures

Tables

NOMENCLATURE

Although all the principal symbols used in this thesis are defined in the text as they occur, a list of them is presented below for easy reference.

r	Compression ratio,
L	length of connecting rod (m),
S	stroke length(m),
V_{disp}	displacement volume (m^3),
θ	angular displacement with respect toBDC (degree).
P_a	Atmospheric Pressure
P_{imf}	Manifold Vaccum Pressure
D	Cylindrical bore diameter
R	Relative Air-Fuel Ratio
C_m	Mean Piston Speed
N_{pr}	No. of Rings
L_{ps}	Piston Skirt Length
N	Speed
P_e	Exhaust gas Back Pressure
G	No. of intake valves per cylinder
H	Diameter of intake Valves
T_g	gas temperature
T_w	Wall temperature
Δt	time for one degree crank angle movement
H	Heat transfer Coefficient

MEP	Mean effective Pressure
FMEP1	MEP lost to friction due to the gas pressure behind rings
FMEP2	MEP absorbed in friction due to the wall tension of rings
FMEP3	MEP absorbed in friction due to the wall tension of rings
FMEP4	Blow by losses
FMEP5	MEP lost in overcoming inlet and throttling losses
FMEP6	MEP absorbed in overcome friction due to the valve gear
FMEP7	MEP lost in pumping
FMEP8	MEP absorbed in bearing friction
FMEP9	Frictional MEP in overcoming combustion and wall and pumping loss

Chapter 1

Introduction

Lately, much analysis and exploration has been completed to discover suitable alternative fuel to diesel and other petroleum items. The utilization of renewable fuels like ethanol, biogas and biodiesel in diesel engines is noteworthy in this connection. The properties of these sources rely on upon the kind of the vegetable oil utilized for the trans-esterification process. Exploratory dissection of the engine with different biodiesel and its blends obliges much exertion and time. Thus, a hypothetical model is created to investigate the execution qualities of the packing ignition engine fueled by biodiesel and its blends. In the present examination, biodiesel is handled utilizing grungy elastic seed oil. A two-stage trans-esterification methodology is produced for the creation of methyl-esters of elastic seed oil. The properties of this biodiesel are nearly matched with those of diesel fuel. The execution tests are completed on a diesel engine utilizing biodiesel and its blends with diesel as fuel. The impacts of relative air-fuel degree and pressure proportion on the engine execution for diverse fuels are likewise broke down utilizing this model. The correlations of hypothetical and exploratory outcomes are introduced.

The regularly expanding vitality requests coupled with the restricted accessibility of fossil fuels and the unfavorable natural impacts coming about because of their utilization, has guided exploration to looking for elective fuels to steadily substitute ordinary ones. Around these, biofuels have gained expanding consideration because of their alluring characteristics of being renewable in nature and lessening the net CO_2 emanations. Biofuels have been utilized as a part of accepted diesel and fuel engines either as slick fuels or as supplements.

1.1 Properties of Rubber Seed Oil

In the present investigation rubber seed oil, a non-edible type of vegetable oil, has been considered as a potential alternative fuel for compression ignition (CI) engines. The rubber seed production potential in India is about 150 kg/ha per annum. The estimated availability of rubber seed is about 30,000 MT/year. Rubber seed kernels (50–60% of seed) contain 40–50% of pale yellow oil. At present, rubber seed oil has not found any major application and hence the natural production of seeds remains underutilized. The fatty acid composition and properties of rubber seed oil in comparison with diesel is given in Table 1 and Table 2, respectively. The purpose of present study is to analyze the suitability of rubber seed oil as fuel for diesel engine and comparison of experimental results with simulation results obtained by Matlab software.

Fig 1-Rubber Seeds

Table 1. Fatty acid composition of rubber seed oil

Fatty Acid	**Composition (%)**
(Saturated)	
$C_{16:0}$ palmitic acid	10.2
$C_{18:0}$ stearic acid	8.7
(Unsaturated)	
$C_{18:1}$ oleic acid	24.6
$C_{18:2}$ linoleic acid	39.6
$C_{18:3}$ linoleic acid	16.3
Others	0.6

1.1.1 Specific Gravity

Biodiesel is slightly heavier than conventional diesel fuel (specific gravity 0.88 compared to 0.84 for diesel fuel). This allows the use of splash blending by adding biodiesel on top of diesel fuel for making blends.

1.1.2 Cetane Number

Cetane number is indicative of its ignition characteristics. The higher is the cetane number affects a number of engine performance parameters like combustions, stability, drive ability, white smoke, noise and emission of CO and HC. Rubber seed oil has a higher cetane number than conventional diesel fuel. This results in higher combustion efficiency and smoother combustion.

1.1.3 Viscosity

In addition to lubrication of fuel injection system components, fuel viscosity controls the characteristics of the injection from the diesel injector (droplet size, spray characteristics, etc.). The viscosity of biodiesel can reach very high levels, and hence, it is important to control it within an acceptable level to avoid negative impact on the performance of the fuel injection system.

1.1.4 Flash Point

The flash point of a fuel is defined as the temperature at which it will ignite when exposed to a flame or spark. The flash point of biodiesel is higher than the petroleum-based diesel fuel

1.1.5 Iodine Number

A high content of unsaturated fatty acids in the ester (indicated by high iodine number) increases the danger of polymerization in the engine oil. Oil dilution decreases the oil viscosity. A sudden increase in oil viscosity is attributed to oxidation and polymerization of unsaturated fuel parts entering into oil through dilution. The tendency of the fuel to be unstable can be predicted by iodine number.

1.1.6 Acid Number

The acid number reflects the presence of free fatty acids used in manufacture of biodiesel. It also reflects the degradation of biodiesel due to thermal effects.

Table 2.Properties of Rubber Seed oil in Comparison with Diesel

Property	Rubber Seed Oil	Diesel
Specific Gravity	0.91	0.835
Viscosity (mm^2/s)	76.4	7.50
Flash point (°C)	198	50
Calorific value (kJ/kg)	37,500	42,250
Saponification value	206	-
Iodine value	135.3	38.3
Acid Value	53.0	0.062

1.2 Effect of dilution and heating on viscosity of blends

It can be seen that the viscosity of rubber seed oil has decreased due to the dilution with diesel. The viscosity reduction increases with the increase in diesel content of the blend. The blends were stirred well so that the mixture was in a stable condition for a longer time. It has been shown that the blends containing 80% of diesel have viscosity and specific gravity close to that of diesel. Heating could reduce the viscosity of oils. Viscosity of blends decreased with increase in temperature and became close to that of diesel at temperature values above 60 °C.

Chapter 2
Modeling of Diesel engine

2.1 Modeling of Diesel Engine

Single zone thermodynamic model is used for analyzing the performance characteristics of four stroke direct injection compression ignition engines. The following fundamental assumptions have been made:

1. Cylinder charge is a homogeneous gas mixture of fuel vapor and air.
2. Pressure and temperature inside the cylinder are uniform and vary with crank angle.
3. Specific heats of the gaseous mixture are calculated as a function of temperature.
4. As the combustion should always be of lean mixture this leads to temperature at which dissociation does not have much effect on thermodynamic performance of the engine.

2.2 Variation of Cylinder Volume with Crank Angle

The energy balance equation can be written as:-

$d(mu)/d\theta = dQr/d\theta - dQh/d\theta - dW/d\theta$

$d(mu)/d\theta$ is the rate of change of internal energy of the system of mass m.

$d(Qr)/d\theta$ is the rate of heat release during combustion period.

$d(Qh)/d\theta$ is the rate of heat transfer from gases to walls.

$d(W)/d\theta$ is the rate of mechanical work done by the system on the boundary.

By rearranging we can get the above equation as

$M du/d\theta = dQr/d\theta - hA dT/d\theta - RT dV/d\theta$

cylinder volume at any crank angle can be computed using the following equation:

equation

$V(\theta) = V\text{disp}\ [(r/r\text{-}1) - 0.5(1 - \cos 2\theta) + 0.5\{\sqrt{}\ (2L/S)^2 - \sin^2\theta\}].$

By differentiating we can get rate of change of cylinder volume with respect to crank angle

$$dV/d\theta = V_{disp}/2[0.5\sin 2\theta/\sqrt{\{(2L/S)^2 - \sin^2\theta\}} - \sin\theta]$$

r is the compression ratio,

L is the length of connecting rod (m),

S is the stroke length (m),

Vdisp is the displacement volume (m3),

θ is the angular displacement with respect to BDC (degree).

2.3 Ignition Delay

The ignition delay in a diesel engine is defined as the time interval between the start of injection and the start of combustion. This delay period consists of (a) physical delay, wherein atomization, vaporization and mixing of air fuel occur and (b) of chemical delay attributed to pre-combustion reactions. Physical and chemical delays occur simultaneously. To reduce NOx, the method adapted in modern engines is to reduce the ignition delay. For predicting heat release in modern engines, therefore, the estimation of ignition delay is no more important. However, the ceiling on NOx is dipping to such a low level that accurate prediction of ignition delay has become important even if it is small. Ignition delay of diesel sprays is a strong function of ambient temperature and pressure. However, the physical delay has not been modeled satisfactorily in the literature. In this chapter, phenomenological calculations of the cooling of spray surface have shown that the physical parameters and fuel type influence the temperature of the mixture of air and the vapors produced by the first parcel of the injected fuel throughout its life up to ignition. A unique thin-ring like zone on the spray surface is postulated where the pre-flame reactions have reached a critical level beyond which uncontrolled reactions take place. The time, at which the spray just touches the ring, the ignition is predicted. However, due to turbulence, ignition will take place at only a few points in the neighborhood of the ring. Detailed consideration of droplet formation, evaporation fuel and pre-flame reaction has enabled prediction of delay period and location of the ignition accurately within the experimental errors and errors in the input to the calculations.

2.4 Heat Transfer

Heat transfer describes the exchange of thermal Energy, between physical systems depending on the temperature and pressure, by dissipating heat. Systems which are not isolated may decrease in entropy. Most objects emit infrared thermalradiation near room temperature.

The fundamental modes of heat transfer are conduction or diffusion, convection, and radiation. During the intake and compression processes heat flows from the cylinder wall to working fluid, whereas during all other processes heat flows from the working medium to wall. The amount of heat exchange between gases to wall as well as wall to gas is considerable and hence it directly affects the engine performance and its life. The method of computation of heat transfer coefficient due to convection is the key factor, which controls the order of magnitude of the rate of heat transfer.

The convection heat transfer, q_c in kJ/degree is given by

$$Q_c=hA(T\mathrm{g}-Tw)\Delta t,$$

Where T_g is the gas temperature (K), T_w is the wall temperature (K), Δ_t is the time for one degree crank angle movement (s).

The heat transfer coefficient, h in W/m^2K is evaluated by using Hohenberg' equation [15] given By equation-

$$h=130P^{0.8}\ (C\mathrm{m}+1.4)^{0.8} / V_c^{0.06}\ T_C^{0.4})$$

Here V_c is the cylinder volume (m^3), C_m is the mean piston speed (m/s)

2.5 Mean Effective Pressure (MEP) Losses

Mean effective losses due to gas behind the rings, wall tension of rings, piston and rings, blow by losses, throttling losses, valve gear, pumping and bearing friction are considered whilecalculating frictional power.

(i) Mean effective pressure lost to overcome friction due to the gas pressure behind rings

$\mathrm{FMEP1}= 0.42*(p_a-p_{imf})*S/D^2*(0.0888*r+0.182*r1.33-0.394C\mathrm{m}60*100)*10.$

Where p_{imf} is the manifold vacuum (bar), D is the cylinder bore (m).

(ii) Mean effective pressure absorbed in friction due to the wall tension of rings

$FMEP2=10*0.377*S*n_{pr}/D^2$,

Where n_{pr} is the number of rings.

(iii) Mean effective pressure absorbed in friction due to piston and rings

$FMEP3=12.85*Ips/(D*S)*100*Cm/1000$,

Where l_{ps} is the piston skirt length (mm).

(iv) Blow by losses

$FMEP4=\sqrt{(pa-pimf)}*[0.121*r^{0.4}-(0.0345+0.001055*r)*(N/1000)^{1.185}]$,

Where N is the speed (rpm).

(v) Mean effective pressure lost in overcoming inlet and throttling losses

$FMEP5= P_e/2.75+ Pimf$,

Where P_e is the exhaust gas back pressure (bar).

(vi) Mean effective pressure absorbed in overcome friction due to the valve gear

$FMEP6=0.226*(30-(4N/1000))-G*H^{1.75} / D^2S$,

Where G is the number of intake valves per cylinder, H is the diameter of intake valve (mm).

(vii) Mean effective pressure lost in pumping

$FEMP7=0.0275*(N/1000)^{1.5}$.

(viii) Mean effective pressure absorbed in bearing friction

$FMEP8=0.0564*(D/S)*(N/1000)$

(vii) Frictional mean effective pressure in overcoming combustion chamber and wall pumping losses

$FMEP9=\sqrt{(Pimep/11.45*0.0915*(N/1000)^{1.5})}$

Total MEP lost in friction = FEMP1+FEMP2+…+FMEP9=$\sum$i=1,9FMEPi.

Chapter 3

Literature Review

Rubber seed containing high amount of free fatty acids (FFA).Biodiesel is commercially produced from the refined edible vegetable oils by alkaline-catalyzed esterification process. This process is not appropriate for production of biodiesel from Rubber Seed oil because of their high acid value. Hence, many researcher and scholars stated their theory and developed different theories for production of rubber seed oil with less fatty acid content some of them are as follows:

3.1 Production of Rubber Seed Oil

Bishop JN. [16] have studied the properties and economics behind the rubber seed oil production as presents different ways of production of rubber seed oil such as Acid catalyzed method, in which high FFA content of non-edible oils are reduced below 3% by using acid pretreatment. It comprises the preheating of oil samples in water bath at 60 °C for 30 min. The acid catalyst mixture (10 ml H2SO4 mixed with 200 ml methanol/ liter oil samples) was added to preheated oil samples and it kept in water bath for 3-4 hrs at 60 ºC. After the reaction, the sample shows two distinct layer such as upper ester layer and lower glycerol layer. The lower glycerol layer was decanted and the upper layer was measured and stored for further study (for alkali catalyzed method).

Muraleedharan C, [18] have stated another method called as alkali/base catalyzed method, in which the pretreated (acid treated) oil samples were heated, addition of alkali catalyst mixture (7.5 gram KOH with 200 ml Methanol/liter oil samples). Then the mixture was shacked and incubated to water bath at 60 ºC for 1-2 hrs. Finally the samples show two distinct layers as that of acid catalyzed method. The top layer was measured and it was saved for purification process. P Ottikutti [7] proposed the purification and also the drying of the product.

3.2 Effects of Different Variable and Parameters

CL Wong [4] have derived expression for variable cylinder volume for different crank angle from Simple energy balance equation and compared the values and plotted graphs between pressure and crank angle for different values of compression ratio. HO Hadenberg [5] have stated the relation between crank angle and temperature for different relative air fuel ratio values. JC Dent [6] have studied the heat release analysis and developed an ideas about heat release from Weibe's heat release correlation. Lyn WT [3] have given brief description about ignition delay and developed an empirical formula from Wolfer's empirical relation.

A.S Ramadas et all have found that 50–80% of rubber seed oil blends gave the best performance. Long run tests were conducted using optimized blend and diesel, when they subjected the blends to engine performance and emission tests and compared with that for diesel. They also found that blend fueled engine has higher carbon deposits inside combustion chamber than diesel-fueled engine. Rakopoulos CD, have found the mean effective pressure losses for different factors and also mentioned about the relation between brake thermal efficiency and compression ratio.

Chapter 4

Methodology

4.1 Experimental Analysis

In the present examination, rubber seed oil, a non-palatable sort vegetable oil, is picked as a potential elective for transforming biodiesel and it is utilized as the fuel as a part of pressure ignition motors. Rubber trees are bottomless in south India. Rubber seed (50–60% of seed) hold (35–55) % of tan hued oil. At present, there is no significant provision for rubber seed oil, subsequently even the regular preparation of these seeds stays underutilized. Then again, the consolidation of high consistency and low instability of rubber seed oil prompts issues in fuel infusion framework, poor frosty motor start-up, failure to discharge, and extra ignition delay. Consequently, it is important to bring the ignition-related properties of rubber seed oil closer to those of the diesel oil. The free fatty acid (FFA) substance of common rubber seed oil is about 18%. Canakci and Van found that basic trans-esterification might not happen effectively if the FFA content in the oil is something like 4%. It was additionally found throughout the present dissection that the basic-catalyzed trans-esterification procedure is not suitable to handle esters from grungy rubber seed oil. At the same time the utilization of refined oils for trans-esterification procedure expands the general preparation expense of the biodiesel. A two-stage trans-esterification procedure is created for transforming biodiesel from an ease-feedstock, for example, unrefined rubberseed:

(i) **Acid-esterification**: Alcohol to vegetable oil molar ratio of 6/1 and 0.7% sulfuric acid (by volume) is used in acid esterification process. The cleaned products of this first step are used as triglycerides for the second step.

(ii) **Alkaline/Base-esterification**: Alcohol to vegetable oil molar ratio of 9/1 and 1.5% sodium hydroxide (by weight) used in the second step and the maximum yield is found. The products are allowed to separate into two layers; the upper layer (biodiesel) is purified to remove the waste and used as fuel in the present analysis.

4.1.1Engine Specification

Manufacturer	CANON
Engine type	Naturally aspirated four stroke single cylinder compression ignitionSingle cylinder, constant speed, air cooled, direct injection, CI engine
Rated power (kW)	5.5
Speed (rpm)	1500 (constant)
Bore (mm)	88
Stroke (mm)	110
Piston type	Bowl-in-piston
Displacement volume (cm^3)	661
Compression ratio	17.5
Nozzle Opening pressure (bar)	200
Start of fuel injection	23 ˚CA bTDC
Dynamometer	Eddy current
Injection type	3- Hole pump-line-nozzle injection system
Nozzle type	Multi hole
No. of holes	3

4.2 Modeling through MATLAB software

MATLAB (matrix laboratory) is a multi-paradigm numerical computing environment and fourth-generation programming language. Developed by Math Works, MATLAB allows matrix manipulations, plotting of functions and data, implementation of algorithms, creation of user interfaces, and interfacing with programs written in other languages, including C, C++, Java, and Fortran. Although MATLAB is intended primarily for numerical computing, an optional toolbox uses the MuPAD symbolic engine, allowing access to symbolic computing capabilities. An additional package, Simulink, adds graphical multi-domain simulation and Design for dynamic and embedded systems.In 2004, MATLAB had around one million users across industry and academia.[3] MATLAB users come from various backgrounds of engineering, science, and economics. MATLAB is widely used in academic and research institutions as well as industrial enterprises.

We can use MATLAB for a range of applications, including signal processing and communications, image and video processing, control systems, test and measurement, computational finance, and computational biology. More than a million engineers and scientists in industry and academia use MATLAB, the language of technical computing.

At first I developed a program for calculating heat transfer coefficient (h). It is very easy to use. Then I started programing for the equation used for calculating cylinder volume. For that equation it needs different variables like stroke length, crank angle, length of connecting rod, compression ratio and cylinder volume. After putting these values we can get cylinder volume and then by changing the value of compression ratio we can plot graph between crank angle and cylinder volume. And then we can compare them by plotting graph in different colors. Then I need the program for calculating different mean effective pressure losses which was also easy and requires different parameters and then we can get mean effective pressure loss by putting the values of different parameters.

Chapter 5

Results and Discussion

The molecular formula of the fuel is given as one of the input to themodel. The performance characteristics of the engine fueled with biodiesel and its blendswith diesel are analyzed by this model. The engine model is analyzed for the variation incompression ratios and relative air-fuel ratios for the different fuels are presented as follows.

5.1 Mean Effective Pressure (MEP) Matlab Coding:

```
clc
clear all
close all

Pa=input('enter atmospheric pressure "Pa" in bar- ');
Pimf=input('enter manifold vaccum "Pimf" in bar- ');
S=input('enter stroke length "S" ');
D=input('enter cylindrical bore "D" in metres- ');
r=input('enter relative air fuel ratio "r"- ');
Cm=input('enter mean piston speed "Cm" in m/s- ');
Npr=input('enter no. of rings "Npr"- ');
Lps=input('enter piston skirt length "Lps" in mm- ');
N=input('enter speed "N" in rpm- ');
Pe=input('enter exhaust gas back presure "Pe" in bar- ');
G=input('enter no. of intake valves per cylinder "G"- ');
H=input('enter diameter of intake valve "H" in mm- ');
Pimep=input('enter manifold vacuum pressure "Pimep"- ');

FMEP=zeros(1,9);
FMEP(1)=0.42*(Pa-Pimf)*(S/(D^2))*(0.0888*r+0.182*(r^(1.33-
0.394*Cm/(60*100))))*10;
FMEP1=FMEP(1);
FMEP(2)=10*0.377*S*Npr/D^2;FMEP2=FMEP(2);
FMEP(3)=12.85*Lps*100*Cm/(D*S*1000);FMEP3=FMEP(3);
FMEP(4)=(sqrt(Pa-Pimf))*(0.121*(r^0.4)-
(0.0345+0.001055*r)*(N/1000)^1.185);FMEP4=FMEP(4);
```

```
FMEP(5)=Pimf+Pe/2.75;FMEP5=FMEP(5);
FMEP(6)=0.226*(30-4*N/1000)-(G*H^1.75)/(S*D^2);FMEP6=FMEP(6);
FMEP(7)=0.0275*(N/1000)^1.5;FMEP7=FMEP(7);
FMEP(8)=0.0564*(D*N)/(1000*S);FMEP8=FMEP(8);
FMEP(9)=sqrt((Pimep/11.45)*0.0915*(N/1000)^1.5);
FMEP9=FMEP(9);
MEP=0;

for i=1:9

    MEP=MEP+FMEP(i);

end
FMEP1
FMEP2
FMEP3
FMEP4
FMEP5
FMEP6
FMEP7
FMEP8
FMEP9
Total_MEP_lost_in_friction=MEP
```

5.2 Matlab code for cylinder volume at any crank angle:

```
function [vol] = volume(Vd,r,theta,L,S)
vol= Vd*(r / (r-1) - (1- cos(theta))/2 + .5*sqrt((2*L/S)^2- sin(theta)^2));


OUTPUT (Sample Calculation)

z= volume(30,15,pi/6,.2,.15)

z =

   69.4238
```

5.3 Matlab code for heat transfer coefficient :

```
function h =heat(P,Cm,Vc,T)
h= 130* (P^0.8)*((Cm + 1.4)^0.8)/((Vc^0.06)*(T^0.4));
```

OUTPUT (Sample Calculation)

s = heat(1,2,3,4)

s =

186.0695

5.4 Effect of Compression Ratio (r)

The gaseous mixtures are compressed to high pressure in the compression stroke by increasing the compression ratio of the engine. The higher the pressure of the mixture the higher its temperature also.In this analysis, with increasing compression ratio of the engine the brake thermal efficiency is also increased for all the fuels. These results support the ideal diesel cycle analysis, that is, brake thermal efficiency is directly proportional to compression ratio and shows the comparison of brake thermal efficiency of the engine with respect to compression ratios for different fuels. It can be seen that the brake thermal efficiency of biodiesel-fueled engine is lower than that of diesel engine. The presence of oxygen molecule in the biodiesel lowers the calorific value and hence the reduction in brake thermal efficiency of the biodiesel-fueled engine. High pressure and temperature of compressed mixture increases its burning rate. This increases the rate of pressure increase and peak pressure inside the combustion chamber.

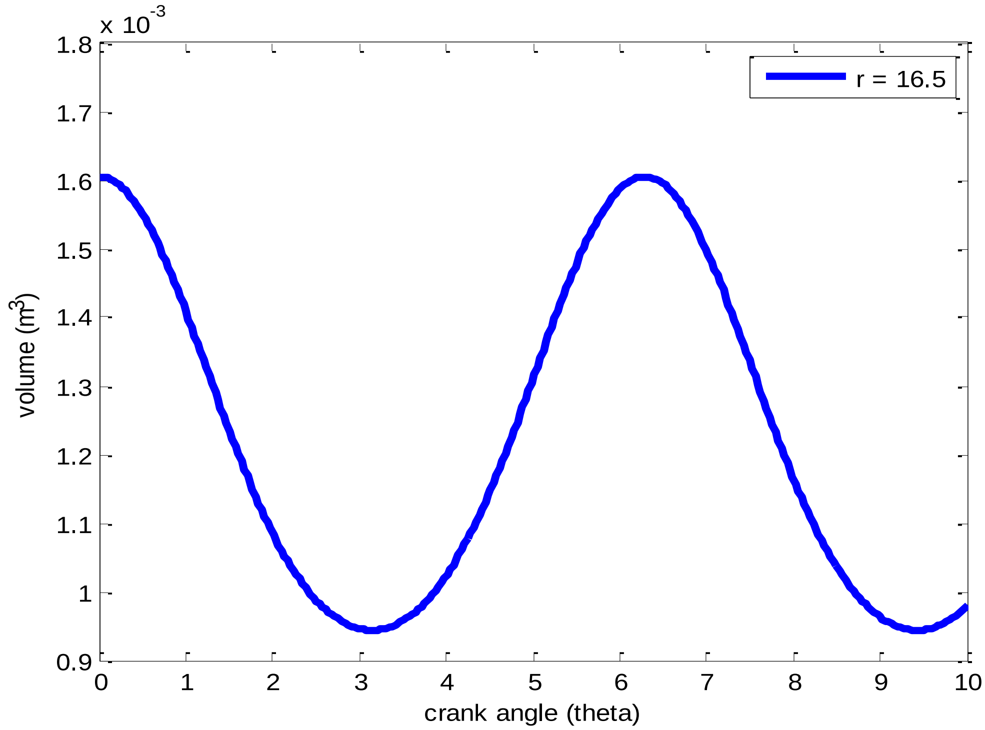

Fig 3. Variation of cylinder volume with crank angle

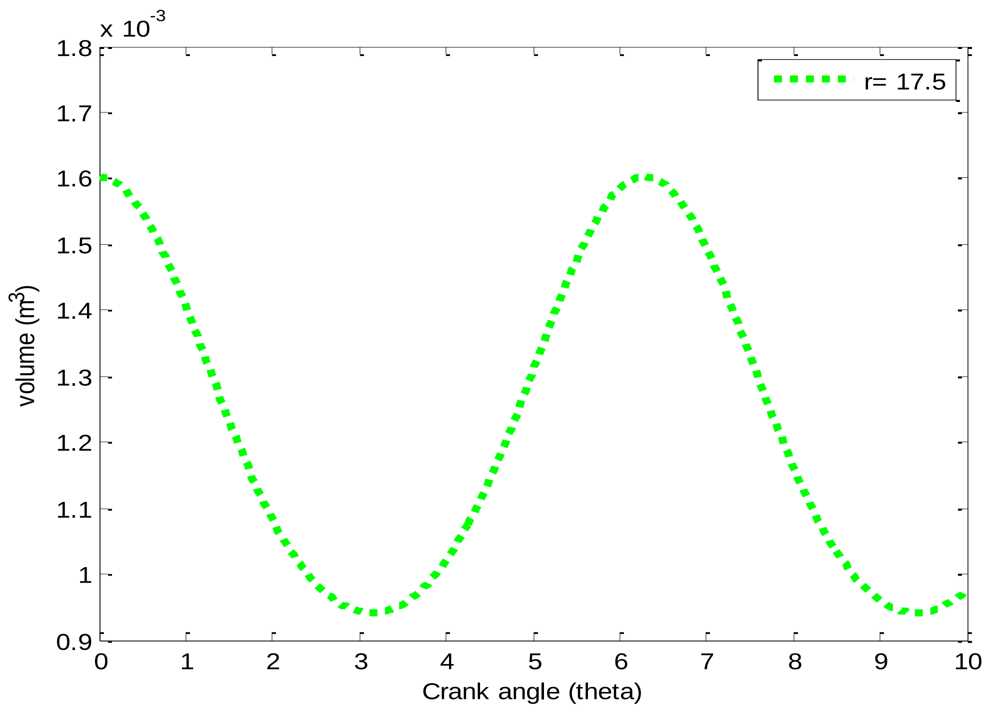

Fig 4. Variation of cylinder volume with crank angle

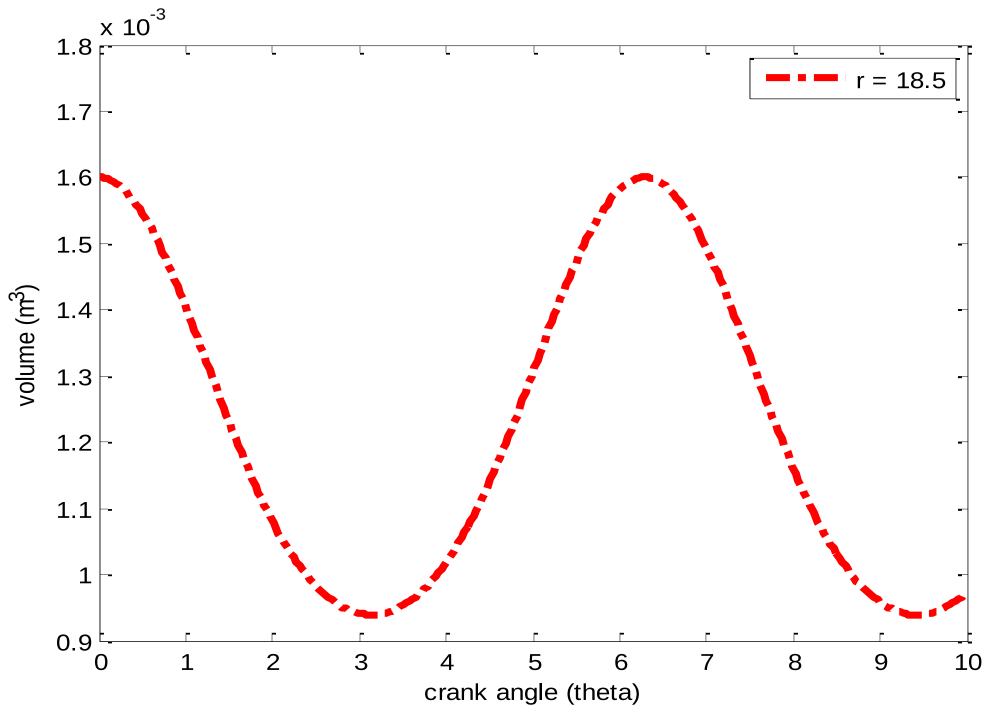

Fig 5. Variation of cylinder volume with crank angle

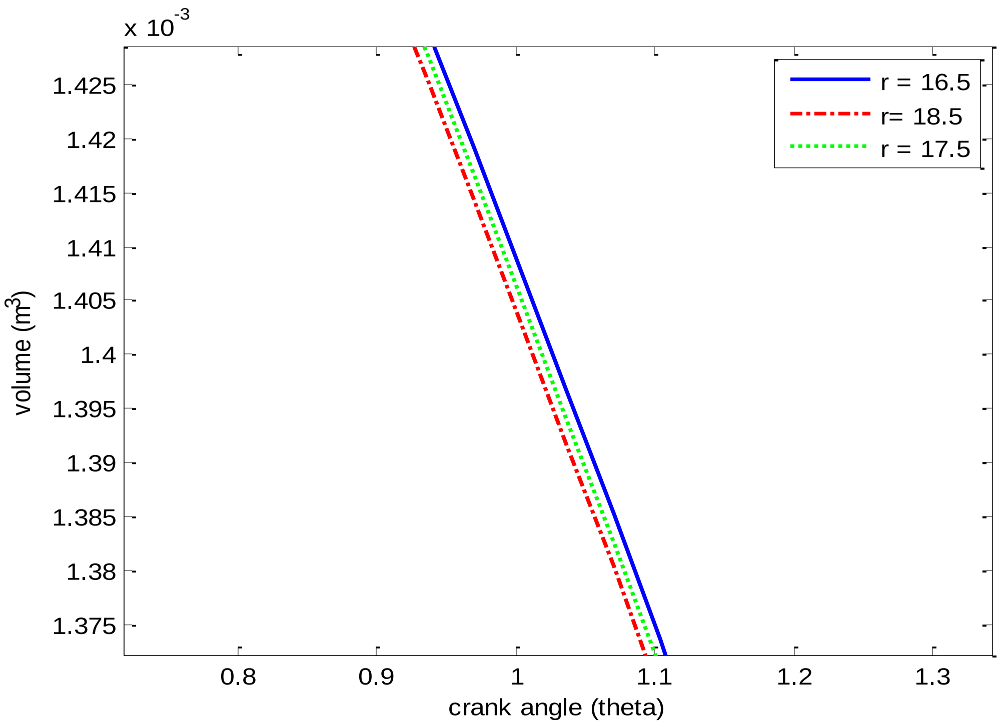

Fig 6. Comparison of varying of cylinder volume with crank angle for different compression ratio

5.5 Effect of Air-Fuel Ratio

The composition of the fuel-air mixture influences the rate of combustion and the amount of heat released. Lean mixture releases less thermal energy and results in lower flame temperatures. Rich mixture results in incomplete combustion and less power is produced. The flame velocity of the mixture will be maximum when the relative air-fuel ratio is one. Hence the time required for combustion is reduced and the peak pressure occurs nearer to TDC. It can be seen that pressure and temperatures are decreasing towards the lean side. Excess air flow into the engine, dilutes the charge and hence lower temperatures are achieved at higher relative air-fuel ratios.

Chapter 6

Conclusion

The aim of the present investigation was to analyze the suitability of rubber seed oil as an alternative for the diesel fuel in CI engine. Simulation and modeling has been done to determine various parameters affecting its performance as an alternative fuel. Modeling and plotting of graphs has been done by using MATLAB software. The following results have been concluded:

- The modeling results showed that, with increase in compression ratio the brake thermal efficiency is increased.
- With increase in relative air fuel ratio the efficiency of the engine is also increased.
- MATLAB program has been coded to calculate different mean effective pressure losses and total MEP lost can be calculated simultaneously by giving the required input parameters.
- Graphs have been plotted for different compression ratio values.

Scope of Future Work

Rubberseed oil is a popular and promising environment-friendly alternative fuel due to its clean burning characteristics. Rubber seed oil is a promoter of the rural economy. In India, research on biodiesel is in advance stage, So there is a need to adopt programs for the commercialization of its production, utilization of its byproducts, and evaluation in engine with respect to emission, additive response, etc. For efficient production of rubber seed oil, concerted Research & development effort is needed to produce high-quality feedstock materials and to develop an improved, cost effective and efficient rubber seed oil production system. Second generation biofuels that are free from the food versus fuel debate will increase the scientific interest in rubber seed oil as a solution to the fossil fuel crisis.

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